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imens of which may always be recognized by their pale color. In Europe, the caterpillar is infested by the larvæ of a *Microgaster*; parasites reared by me perforated the skin of the caterpillar August 19th and made their cocoon on its body. September 4th the box containing the cocoons was opened, disclosing both dead and living imagines; they belonged to two distinct species, those of the smaller being dead and dry, while those of the larger were either living or recently dead; on the succeeding day the remainder of the larger ones appeared, and proved to be, as identified by my friend Mr. Drewsen, of Copenhagen, *Microgaster sub-completus* var. ? von Esenb., and the smaller an undetermined species of the same genus, probably undescribed. Of the former 3♂ and 15♀ emerged; of the latter 8♂ 3♀; besides these, four larvæ had been taken from their cocoons and preserved in that state; all of these came from the body of a single caterpillar. The larger species is probably the actual parasite of *V. cardui*; the latter, a parasite of the parasite.

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## AQUARIA: THEIR PAST, PRESENT, AND FUTURE.

BY WILLIAM ALFORD LLOYD.

**E**IGHTY-SIX years ago—in the year 1790—there might have been seen trudging along the streets of Edinburgh an “old blue-coated serving-man,” carrying an earthenware pitcher or jar, of three or four gallons’ capacity. That pitcher contained sea-water for the marine aquarium of Sir John Graham Dalyell, Bart., who thus employed a man, or probably a succession of men, from the time he began aquarium-keeping till he finished at his death in 1851, a period of sixty-one years. The jar was sent to the sea to be filled twice or thrice weekly; but averaging it at five times a fortnight, and allowing four miles for each double journey from Great King Street to the sea and back, that amounted to 39,650 miles from the year 1790 to the year 1850, which was an enormous and perfectly needless expenditure of force, expressed in time and money, even although the results of Sir John’s investigations were given to the world in five such important quarto volumes as his *Rare and Remarkable Animals of Scotland*, 1847–48; and his *Powers of the Creator* displayed in the *Creation*, 1851–58.

Dalyell’s mode of operation, as told to me by his sister Elizabeth, in two letters dated 1860, and printed in the *Zoölogist* of

November, 1873, vol. viii., second series, pp. 2757, 2758, was as follows: He kept his living marine animals, consisting of the lower kinds below fishes, in a number of glass cylindrical jars, of various sizes and proportions, and with usually one animal in each. The water in these jars he changed every morning, "often twice a day, if he perceived the smallest fragment amongst it, wiping and washing the glasses very clean." He then drew away the water so used, and replenished it from the earthenware jar with the water got from the sea. At one time I should not have termed this aquarium-keeping at all, because of the change of water. (See *Crystal Palace Aquarium Handbook*, 1875, p. 7.) But now, having got to think more broadly, I recognize this, not as a change of water in the sense of its being lost, but merely as a change of position from a house in Edinburgh to the sea, and back again. That is to say, the water he dismissed from his jars went into a gutter in a street, or into a sewer below it, and found its way by gravitation into the ocean again. Or, if it were poured on the ground, into which it soaked, it found its way back to the sea by an infinitely more circuitous route. But had Dalyell been more of a general philosophical thinker as well as a naturalist, he would have saved himself this very great amount of cost and trouble. Had he but reflected on that which was then known, namely, that water — both sea-water and fresh water — is practically indestructible, and that any decaying organic matter, animal or vegetable, or both mixed, can be got rid of, and the water be left pure, then he would have saved his servants their weary walks of more than as far, in their aggregation, as twice round the world, nearly.

In the ocean, of course, various animals and plants are incessantly dying in large numbers, and their decomposing remains are prevented from permanently poisoning the water, in which other animals live and breathe, by the incessant motion to which the sea is subjected, and this motion brings the water into purifying contact with the atmospheric air which everywhere exists. It is this air, or rather the oxygen in it, which the water takes up in greater quantity than the nitrogen, which is another and larger component of the atmosphere, which is the source of purification alluded to, the water being merely a medium or a vehicle for the exhibition of the oxygen. In addition to this, vegetation grows by the action of light, and decomposes the poisonous carbonic acid gas evolved by the breathing of animals, the carbon being used to form the woody substance of the plants, and the

residual oxygen being liberated for the use and benefit of the animals. Thus the ocean, and rivers, and lakes, and all other waters in nature, of varying degrees of freshness and saltiness, by motion and vegetation, both originating from the sun, are maintained sufficiently pure and respirable.

These operations were going on almost at Dalyell's door, yet he did not learn to apply them to practice, as he might have done. What he did was this: He fed the animals in his jars on mussel flesh, which is easily diffusible in water, and which quickly makes it milky; and this, with the absence of growing vegetation, and the breathing and other emanations of the animals, soon caused the water to become offensive in appearance and in smell. So he threw it away. But the very act of pouring it, and the motion of it as it trickled onward to the sea, purified it, because such an act was an unconscious imitation of what nature does. Had Sir John but thought of the merely vehicle character of water, and of its incapability of being decomposed save by a very slow and expensive process, he would at once have seen that the minutely disseminated mussel flesh and its juices in the water made that water unfit to support life, only temporarily. It was not the water itself that was not fit; it was only something in the water that was wrong, and if that something were removed the water would be left as good as ever. If, therefore, instead of sending it back into the sea by a long road, and then going to the immense pains to dip it back again, he had poured it into a large receptacle in his own house, such receptacle or reservoir being many times larger than the aggregate contents of all his glass jars, he would have found that in a short time he would have possessed a source of supply for the jars quite as good as the ocean provided. Had he, in addition, placed his reservoir in a cool cellar, and had a pipe connecting it with the study to which Miss Dalyell has incidentally alluded, with a funnel at the upper end of the pipe, in which was placed a piece of straining-cloth or a small hair-sieve, to arrest the coarser pieces of decaying organisms, and if he had poured the water he had used into this funnel, the arrangement would have been still better. Yet better would it have been had he possessed another pipe leading upward from the reservoir, through which he could pump up the sea-water as he wanted it. Best of all would have been some form of incessantly-working machinery, by means of which the water would be always coming up, day and night, from this large and cool reservoir into the experi-

mental glasses, for then they would have been constantly kept at an even temperature and in a state of constant aeration. This would have done away with the necessity of the everlasting wiping and washing of the glasses ; and, they being thus left alone, and in a certain amount of daylight, vegetation would soon have appeared in them, stimulated by the action of that light, without having been visibly introduced, but present everywhere in the seeds or spores of plants, merely waiting to be developed. Such an arrangement, indeed, would have been precisely that of the best modern aquaria as now made, in which the water is so continually and abundantly aerated by ceaselessly moving machinery that impurities have no time to accumulate, but are oxygenated and dissipated as quickly as they form. In the Brighton and Havre public aquaria, the old and intermittent system used by Dalyell has been reverted to, and of course with ill results, as the water freshly obtained from the sea is turbid when seen in large masses, and is unhealthy for the animals, only a small number of which therefore can be kept in great bulks of fluid, because it is insufficiently aerated. This will be the case also at the Scarborough aquarium, now being built on the same erroneous principle.

Dalyell, however, was no mechanician or physicist, and he knew nothing of marine botany ; so he just did as his neighbors did with their fresh-water gold-fish globes ; he changed the sea-water and threw it away as quickly as it became sullied, and this water he obtained at no great cost, he living close to the sea. Or if the cost of time in getting it was considerable in proportion to the work done, *i. e.*, the quantity obtained, it mattered not much to him, as he was a rich man. Yet, had he but known it, the sea-water he thus obtained was less good for the animals he kept than it should have been, inasmuch as it was from the adjoining Firth of Forth, and of the density of but 1.024, at a temperature of 60° F. ; whereas had he kept it for some months, it would have evaporated to the more proper density of 1.027 at 60° F., taking distilled water as being 1.000 at 60° F.

I have given this narration as showing the state of things aquariaally at the end of the last century, and during the first half of the present one, and also as being the mode of operation which the general public, and even the great mass of the higher and better educated classes of society, still believe to be the system necessary to be followed in the maintenance of aquaria.

In the year 1842, the late Dr. N. B. Ward published the first

edition of his book, in 8vo, on the growth of plants in closely glazed cases, and this in 1854 was followed by the second edition, in 12mo. In 1853, Dr. N. B. Ward's son, the present Dr. Stephen H. Ward, gave a lecture on this subject at the Royal Institution, which was published as a 12mo pamphlet in the same year. All three of these are now and have been long out of print, and they bear testimony, indubitably, that N. B. Ward experimented with aquaria about the year 1840, though he did not use the word "aquarium," which was employed for the first time in print, as far as I know, twice by Mr. P. H. Gosse, in his *Devonshire Coast*, post 8vo, 1853, at pages 234 and 441. That is to say, N. B. Ward is the earliest recorded person who *intentionally* arranged together certain animals and plants in water, so that these two sets of organisms should mutually and partly support each other, the plants giving off oxygen and taking up carbon, and the animals taking up oxygen and giving off carbon, thus decomposing and rendering harmless the carbonic acid gas as continually as it was evolved by the animals, and maintaining the water pure. In Dr. S. H. Ward's pamphlet, just named, is a long, circumstantial, and most interesting narrative of how Mrs. Anne Thynne did the same thing precisely with sea-water and marine animals and plants. This lady being in London in the year 1846, and having some living corals and sponges, used to send occasionally to the coast for supplies of water for her creatures. But finding that if a quantity of this water were taken up in a jug and let fall again from its spout in a slender stream, it lost whatever impurity it contained from contact with air in this much comminuted state, she ceased to get more from the sea, and instead got from thence some living sea-weed and placed it in the water, which derived additional benefit from this vegetation, just as Dr. N. B. Ward found his fresh water had benefited by the plants he introduced. It is more than probable, however, that in both these instances the really beneficial vegetation was not that which was thus visibly introduced, but was the minute kind which grew parasitically on the plants and upon the inside of the vessels. Yet it must be admitted that this gentleman and this lady are the two first known persons who, keeping a chemical law in view, deliberately and purposely set about attaining means for its fulfillment in an aquarium.

In 1849, the late Mr. Robert Warington, chemist to the Company of Apothecaries, set up in his rooms, in the hall of that

company, in London, his first aquarium, a fresh-water one, followed, in 1851–52, by his first marine aquarium. These he described in the periodicals of the day, and also in a lecture which he gave at the Royal Institution, in an interesting manner, and naturally from a chemist's point of view. At about the same period Mr. P. H. Gosse commenced his earliest marine aquarium, as did Dr. J. S. Bowerbank, Dr. Cotton, and the late Dr. E. Lankester, and the successes attained by these experimenters induced the Zoölogical Society of London to determine to have a public aquarium in its gardens in Regent's Park. The building for this purpose was erected in the spring and summer of the year 1852. The marine and fresh-water animals were begun to be introduced in the late autumn ; the following winter and spring were wisely spent in experimenting on the best modes of operating, and the exhibition was opened on May 21, 1853. After having been noticed in print by the *Athenæum* of some months earlier, it was again commented upon by that journal of May 28th, and by the *Illustrated London News* of the same day and year, the latter publication giving views of two tanks. One of the earliest services which this institution conferred on biological literature may be seen in portions of the natural history division of the English Cyclopædia (an adaptation of the earlier Penny Cyclopædia), as the former publication appeared fortnightly, commencing in the spring of 1853 ; and as it was edited by Dr. E. Lankester, who always took much interest in aquaria, he mentions in the book from time to time that such and such animals named had been kept in this Regent's Park aquarium, to which he gave the needlessly long name of "aquavivarium." This place was my own much loved and earliest place of natural history studies, and in August, 1853, I too arranged a little domestic aquarium of my own — a fresh-water one. Later in the same year I set up a small marine one, or rather a series of little aquaria in glass jars, holding from half a pint to a pint each. Seldom has a student begun with such very small means as I then possessed, for my sea-water was compounded of salts purchased at a London chemist's shop, and my animals were such little sea-anemones as I could find uninjured on oyster shells thrown into London streets. I was in earnest, however, and the difficulties I was so closely beset with, and they alone, enabled me to gain subsequent success. In the earlier books on aquaria — notably in Mr. Gosse's two volumes, his *Devonshire Coast* and his *Aquarium* (the

latter having gone through two editions, 1853 and 1856, besides a recent reprint without the plates, which have been accidentally destroyed) — aquaria are associated in idea with conservatories, especially as to the growth of plants in each. This notion was very natural. Accordingly the Regent's Park Aquarium was made virtually as a conservatory. But it was a diametrically wrong notion, as the first summer proved ; and the second summer (1854) showed this still more conclusively ; and the third (1855) yet more so, the evil being an accumulating one. It was then remembered, when too late, that marine and fresh-water plants and animals live in seas and rivers, where the temperature is much more restricted in range than that which obtains in the atmosphere.

It was seen that success was to be obtained by representing these conditions of nature just named, and that to place such organisms in a glass house, where the rays of a summer's sun heated a mass of imprisoned air, was to kill the animals and to stimulate the plants to unnatural growth, or rather to cause them and some of the animals to be covered with a parasitic growth of the lower green algæ, which obscured them. The errors of this earliest aquarium were strikingly shown by its solitary merit, the latter being its fresh-water division, occupying one side of the building, where the water coursed through the tanks in a constant stream, it being clear and cool, and peopled with an adequate number of healthy animals ; while on the other side of the building, and in its centre, were the marine tanks, in which the water was, and still is, turbid and warm, and sparsely inhabited by not healthy creatures.

These good results were, however, obtained by accident and not design. The society possessed already a steam-engine, which pumped up water for the general use of its gardens, and it was a mere matter of course to connect the aquarium with this engine, and allow the water (which *chanced* to be drawn from a pure source) to run through the fish tanks, and then be applied to ordinary purposes, drinking or other, for which its passage through the tanks in no way unfitted it. I reasoned with the society that if the sea-water tanks were similarly treated on some such system as the fresh-water series, a correspondingly good result would be attained ; and I pointed out that the same law governed both, because in the centre of the building were some isolated fresh-water tanks having no stream in them, and these were in a similarly ill condition as the marine tanks by



their side. In reply, the society answered that a circulatory system did exist in a part of the sea-water series, but that it was almost useless ; and I then pointed out that that was because the reservoir into which the sea-water entered after it had run through the show-tanks was too small in relation to the dimensions of the latter, and that the reservoir should be several times greater than the show-tanks. My reasoning was all in vain, however, for the society went on throwing away the sea-water when it was only *temporarily* unfitted for use, and getting at a cost of several hundreds of pounds yearly a weekly supply from the sea, especially when soon afterwards another evil made its appearance, consisting of a greenish-brown dense opacity, permeating the water and quite hiding from view all it contained. This was caused by excess of light, for I found that darkness removed it and made the water clear again ; and this led to Mr. E. Edward's invention of the dark-chambered tank, a modification of which is now, or should be, employed in all public aquaria where adequate results are aimed at and attained. So, at this early period, 1853-62, though in theory the Zoölogical Society of London, and every one else who maintained aquaria, used the same unchanged water, especially sea-water, yet most persons sent to the sea, or to dealers, of which I was then one, for occasional new supplies. However, from 1853 to 1855, when I could not possibly get new sea-water for my little jars, I merely increased the quantity of water to about eight or ten times as much as those jars collectively held. Thus the aggregate contents of my jars were about six or eight pints ; and in a now historical earthenware foot-pan, kept dark in a cool corner at hand, I had five or six gallons more water, containing neither animals nor plants, and when aught occurred to disturb the equilibrium of life in these jars, either from excess of light or heat by standing on a light window-sill, or from excess of food, or from there being too many animals in a small space, instead of throwing away the water thus *temporarily* rendered unfit to sustain life, I merely restored it to a right condition by pouring the contents of these jars into the foot-pan, which was so large in relation to the dimension of the jars that I could immediately dip them up full from it (the foot-pan) without the water being perceptibly the worse for it, especially when I so contrived matters that these transfers were made, not in one day, but on successive days. Thus, in London, far from the sea, which I had never seen, I was so far, aquariaally speaking, as well off as the

wealthy Sir John Graham Dalyell, with the ocean almost at his door. Later on, in 1857-58, I set up another marine aquarium, in which the show-tank held twenty gallons, and the reservoir five hundred gallons of water, in which that water, instead of being intermittently circulating, as in my jar and foot-pan arrangement, circulated constantly, day and night, by means of a pump and pipes, in a cool underground London cellar or kitchen, with a uniform temperature of about 60° F. This answered excellently, especially when I increased the water in the reservoir to one thousand gallons.

As the more air there is in the water the better it is, hence the value of large and therefore cool reservoirs. Independently of all this, however, the larger the bulk of water, and the more constant and vigorous the circulation and aeration, the less it will be sullied by the animals which live in it. In the Crystal Palace Aquarium we have in the show-tanks twenty thousand gallons of sea-water, and in the reservoir one hundred thousand gallons, total one hundred and twenty thousand gallons, supplied by Mr. W. Hudson in 1870. Yet in this comparatively small quantity of unchanged fluid we have, from September, 1871 to March 31, 1876 (four and a half years), given to the animals in it the following enormous quantity of food without the water being otherwise than always sparklingly clear :—

1. Sandhoppers ( <i>Talitrus</i> ), in pounds weight	12
2. Shrimps ( <i>Crangon</i> ), in quarts	4735
3. Crabs ( <i>Carcinus</i> ), in gallons	137
“ ( <i>Cancer</i> ), large, “ numbers	1450
4. Scallops ( <i>Pecten</i> ) large, in numbers	32
5. Oysters ( <i>Ostrea</i> ) “ “	2195
6. Cockles ( <i>Cardium</i> ), in gallons	18
7. Mussels ( <i>Mytilus</i> ) “	3544
8. Whelks ( <i>Buccinum</i> ) { in gallons	7
“ “ numbers	100
9. Fish, chiefly Whiting ( <i>Gadus</i> ), in pounds weight	3159
10. Smelts' roe ( <i>Osmerus</i> ) “ “	14
11. Green sea-weed ( <i>Ulva</i> ), purchased	400
12. “ “ ( <i>Confervea</i> ), grown in tanks, quantity unknown.	

And, in addition, we obtain occasional and unrecorded supplies from neighboring fishmongers when the regular supply runs short. Of this animal food, all but the denominations nine and ten are kept alive in a series of reserve tanks till the moment of being eaten. Scarcely any uneaten food, and never any excrement, is manually removed ; but all which is not consumed by the animals is chemically dissipated, without filtering, by the enormous volumes of air constantly being injected into every

tank by Leete Edwards and Norman's machinery, the speed of which is accelerated (*i. e.*, the oxygenation is quickened) when the water is slightly turbid from an excess of organic matter. All this I have explained more at length in the Official Handbook to the Crystal Palace Aquarium, and in Observations on Public Aquaria, both published at the Crystal Palace. It is this power of oxygenating, or consuming, or burning, at a low temperature, termed by Baron Liebig "eremacausis,"<sup>1</sup> which expresses the real work done in an aquarium, and the force necessary to do that work. Even our thick beds of sand and shingle at the bottom of each tank are so fully charged with air that one thrust of a stick will release a pint of it in bubbles. This is a source of purification and health quite unknown till recently. Consequently the floors of our tanks (excepting the sea anemone tanks) are as speckless and as free from the blackness caused by sulphureted and carbureted hydrogen gas, as on the day they were laid down in 1870. If we have an excessive growth of sea-weeds anywhere, we turn in a shoal of gray mullet (*Mugil capito*), which nibble it down close, like sheep in a field of grass. This leads me to say that at present we do not know how to grow the higher marine algæ, the red, the brown, or even the green kinds, at will. Sometimes I succeed, but always by chance, not knowing why.

Of the general influence of aquaria on zoölogy we have curious evidence in Mr. Gosse's most excellent Manual of Marine Zoölogy for the British Isles, published in two volumes, in 1855-56, in which the author enumerates 1785 species, from sponges to fishes, and of which he figures 779 genera, always preferring to draw from living animals whenever possible. Now, as at that period a larger number of aquarium animals had passed through his hands than through those of any other person, he may be presumed to have, up to then, seen more of them alive than any one else. Yet he enumerates only 201 as having been drawn from life, as he avowedly preferred doing, and of these but a dozen were fishes, others being, for the most part, small creatures, or those which are easily maintained and do not need large tanks and elaborate machinery. But during the twenty years which have elapsed since 1856 I have seen and handled and had under my care, in England, France, and Germany, about 433 species of British marine animals, of which 112 were fishes.

<sup>1</sup> From the Greek "to remove by burning, or by fire." The words "caustic" and "cautery" have the same derivation.

There are few things more trying to that great virtue, patience, than a large public aquarium, especially in its preparation, before it is ready for the reception of animals. It is to this lack of patience on the part of the directors of the Royal Westminster Aquarium, and to their absolute refusal to allow me to have proper engineering assistance during its construction, and to general mismanagement, that its present confused state, and its unsatisfactory condition in every way, is due. On this account I resigned my post of adviser to the society, as I found it useless to advise when advice was recklessly disregarded. Aquarium work, being hydraulic engineering on a small scale, is essentially the work of an engineer, and not that of an architect, unless he is also an engineer and a mathematician. There is for aquaria a great and important future, both as regards their influence on science and as pecuniary speculations, if indeed, as I much doubt, there can be any real severing of these two interests. Success, however, must always be the result of a careful study and representation of what nature does, and of a strict avoidance of the recent heresies to which I have in this communication adverted. — *Popular Science Review*.

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#### RECENT LITERATURE.

TWO YEARS IN CALIFORNIA.<sup>1</sup>— This book contains apparently a reliable and useful account of California, its scenic and climatic features, its people, with hints for tourists and settlers, and a candid chapter on the Chinese in California. The authoress gives these people credit for a business sagacity, fidelity, industry, and economy which render them a desirable class of immigrants. By their aid, it is claimed, the natural wealth of California has been advanced beyond what it would otherwise have been by a quarter of a century. The literary execution of the book is not rarely capable of improvement, but the work is the result of an honest attempt to impart the fruits of close observation during a two years' residence in California.

COOK'S MANUAL OF THE APIARY.<sup>2</sup>— A cheap and reliable manual of bee-keeping has been needed by amateurs and beginners in the art, and here we have in print Professor Cook's lectures on the subject, delivered annually to his students, forming a guide which we can unhesitatingly commend as sufficiently scientific and practical. The Italian variety is recommended as greatly superior to the German. As regards the treatment of foul brood, we would inquire whether carbolic acid or

<sup>1</sup> *Two Years in California*. By MARY CONE. With Illustrations. Chicago: S. C. Griggs & Co. 1876. 12mo, pp. 238. \$1.75.

<sup>2</sup> *Manual of the Apiary*. By A. J. COOK. Lansing, Mich. 1876. 8vo, pp. 59.